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DECLARATION

The undersigned, Jan McLin Clayberg, having an office at 5316 Little Falls Road, Arlington, VA 22207-1522, hereby states that she is well acquainted with both the English and German languages and that the attached is a true translation to the best of her knowledge and ability of international patent application PCT/DE 03/02514 of Koch, S., et al., entitled "CIRCUIT ARRANGEMENT AND METHOD FOR OPERATING AN ELECTRIC MOTOR IN A DIRECT VOLTAGE NETWORK".

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.


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CIRCUIT ARRANGEMENT AND METHOD FOR OPERATING AN ELECTRIC
MOTOR IN A DIRECT VOLTAGE NETWORK

5 The invention is based on a circuit arrangement for
operating an electric motor in a direct voltage network, in
particular for operating a permanent-magnet-excited DC motor
in the direct voltage network of a motor vehicle, of the kind
that has been disclosed by German Patent Disclosure DE 101 17
252 A. This reference shows an electronically commutated two-
10 phase electric motor, with a rotor excited by permanent
magnets and with two windings in the stator that are supplied
with current in alternation by an electronic controller via
power switches, in which to regulate the electric motor,
individual current supply periods per unit of time are
suppressed by the electronic controller. The motor rpm is
15 predetermined by the electronic controller from the
comparison between an actual rpm and a set-point rpm, but the
reference provides no information about the determination of
the actual rpm. Nevertheless, the use of Hall transducers for
this purpose is well known.

20 In addition, electric motors with electronic
commutation are also known for use in motor vehicles; they
have a rotor equipped with permanent magnets and a stator
that carries the windings. In the motor vehicle, the areas in
which such motors can be used are particularly in the field
25 of ventilation, pumps, and adjusting drive mechanisms. The
supplied current and the magnitude of the load moment
determine the rpm; the rotary motion results from the supply
of current to the stator windings, controlled on the basis of
the rotor position, from a direct voltage network. The
30 electronic controller is as a rule embodied by a
microcontroller (μ C) or a digital signal processor (DSP), and
the commutation is controlled by a rotary position transducer

whose exact positioning is essential if the commutation time of the motor is to be maintained in operation.

The object of the invention is to enable setting the commutation time without mechanical, or in other words
5 without changing the position of the rotary position transducer, taking existing tolerances for the individual motor into account. This is attained by the definitive characteristics of the independent circuit and method claims, which make it possible to compensate for the total tolerances
10 of mechanical, magnetic and electronic components after the motor has been assembled and thus to optimize the efficiency of the motor. For a pump motor, for instance, this optimization means setting the highest possible pumping power of the motor for a given driving moment.

15 It has proved advantageous if the electronic commutation controller is formed by a microcontroller with a delay in the output signals, which is preferably achieved by means of waiting cycles of the microcontroller after the detection of the signal change of a rotary position
20 transducer. Expediently, the supply of current to the armature winding coils is effected via electronic power end stages, such as MOSFETs, to which the delayed output signals of the microcontroller are supplied as control signals. The delay correction is preferably effected as a function of rpm, so that depending on the rpm at the time the optimal
25 commutation time can be maintained. Bipolar Hall ICs are especially suitable as rotary position transducers; because of their small structural size and their invulnerability to elevated temperatures, they are especially suitable for
30 installation in electric motors, and in particular for installation in electric motors used in motor vehicles.

The circuit arrangement and the method of the invention are especially advantageously usable, because of their simple, inexpensive design, in electric motors used in large numbers, especially in the electric motors, often used in motor vehicles, that have two oppositely wound armature coils that are supplied with current in alternation via two electronic switches. The electronic commutation correction in the signal of the rotary position transducer, set to an early commutation time upon assembly, is possible in an especially simple way because the correct setting for the individual motor is ascertained once and for all by means of an external measuring device and stored in a permanent memory of a microcontroller, used as a commutation controller, or in an external memory. If the commutation controller additionally receives the rpm of the motor at the time, ascertained for instance from the spacing between signal edges of the rotary position transducer, then the triggering of the armature coils of the motor can additionally be done in a chronologically variably delayed manner.

Further details and advantageous refinements of the invention will become apparent from the dependent claims and the description of the exemplary embodiment of the invention.

The drawings show a fundamental illustration of the timing member of the invention.

In the drawings, 10 indicates a permanent-magnet-excited, electrically two-spooled DC motor, which is embodied magnetically with a single phase and is designed for instance as a claw pole motor. Seated in the stator 12 are two oppositely wound coils 14, 16 on a magnet armature 18. A rotor 20 of the motor 10, embodied with two poles or with a

number of poles equivalent to an integral multiple of two, is designed as an inner rotor. One version of such a DC motor 10 has, per coil, an inductance of 5 to 6 mH and a resistance of 1 to 3 ohms.

5 The motor 10 is connected via two electronic switches
22, 24 to a direct voltage network having a positive pole 26
and a ground pole 28. MOSFETs preferably serve as the
switches 22, 24. The switches are triggered via an electronic
commutation controller, with a microcontroller that has two
10 delay members T1, T2, which output the trigger signals to the
switches 22, 24 in delayed fashion. A bipolar Hall IC 32,
which is connected to the direct voltage source 26, 28 and
furnishes the information about the position of the rotor 20,
in accordance with the flow direction, either N/S or S/N, to
15 the microcontroller 30, serves as the rotary position
transducer. The microcontroller further includes a permanent,
nonvolatile memory T, which serves as a long-term memory for
the optimal commutation time, measured by an external
measuring device 34 for the individual motor, taking all the
20 tolerances into account. The values stored in the read-only
memory T determines the correction of the rpm transducer 30,
calibrated to an early commutation time upon assembly.
Instead of the internal memory T of the microcontroller,
however, an external memory may be used.

25 The circuit arrangement shown functions as follows:

As already noted above, upon assembly of the motor 10,
the Hall IC 32 used as a rotary position transducer is
secured to the stator 12 of the motor 10 and calibrated such
that it signals an early commutation time, determined by the
30 position of the rotor 20, in accordance with the signal edge

of the Hall IC 32 that is tripped by the variable magnetic field of the rotor. The amount of the delay between the signal edge of the Hall IC 32 and the signal output of the microcontroller 30 via the timing members T1, T2 is
5 ascertained by the measuring device 34 connected once and for all to each motor and is stored as a delay value in the read-only memory T. The latter is preferably embodied as a FLASH memory, EPROM, or EEPROM, so that in principle, even a later
10 correction of the delay value, for instance by means of changes in tolerances that occur during operation, is possible.

The position of the rotor 20 determines which coil 14, 16 is to be supplied with current; in the magnetically single-phase motor shown, only one coil at a time is supplied
15 with current. For instance, upon the input of a signal of the Hall IC 32, only the motor coil 14 on the left receives current. The switch 24 associated with the motor coil 16 on the right remains open until a changing edge of the signal of the Hall IC 32, in accordance with a change in the flow
20 direction in the rotor 20, arrives at the microcontroller 30. At this instant, the coil 14 on the left is switched off via the switch 22 on the left, and the coil 16 on the right is supplied with current in delayed fashion. This delay is preferably variable in accordance with the rpm of the rotor
25 20, since with a variable rpm, the ideal commutation time of the motor also varies. The rotary speed of the rotor 20 is determined from the time interval between two signal edge changes of the Hall IC 32, which correspond to a change in the field direction of the rotor 20. The measuring device
30 34 is not part of the individual motor 10 but instead belongs to the production equipment for assembling the motors.

In operation, in addition to the input signal of the Hall IC 32, the microcontroller 30, via a further control input 36, receives a signal for the set-point rpm of the motor 10, which is compared with the actual signal of the Hall IC 32 and switches the electronic switches 22, 24 to be conducting.

Hence the nucleus of the invention is delaying the commutation time by means of waiting cycles within the microcontroller 30 after a signal change furnished by the Hall IC 32 is detected. The length of the delay is programmed once and for all, with the aid of the measuring device 34, taking into account the total tolerances, which fundamentally remain the same, of mechanical, magnetic and electronic components after the assembly of the motor, in order to attain an optimization of the efficiency of the motor, for instance the optimization of the pumping output of a pump motor. However, the use of the invention is not limited to such a motor; on the contrary, it is usable in the same way for other electronically commutated motors as well, especially other brushless DC motors, specifically and preferably whenever the detection of their commutation is effected by means of a Hall IC.